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QUALITATIVE AND NUMERICAL ANALYSIS OF A COSMOLOGICAL MODEL BASED ON AN ASYMMETRIC SCALAR DOUBLET WITH MINIMAL COUPLINGS. I. QUALITATIVE ANALYSIS OF THE MODEL

Yu. G. Ignat'ev and I. A. Kokh

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A qualitative analysis of a cosmological model based on the asymmetric scalar doublet classical + phantom scalar field with minimal interaction is performed. It is shown that depending on the parameters of the model, the corresponding dynamical system can have 1, 3, or 9 stationary points corresponding to attractive or repulsive centers (1–5) and saddle points (0–4). A physical analysis of the model is performed.

Keywords: cosmological model, asymmetric scalar doublet, qualitative analysis.

1. THE BASIC EQUATIONS OF A COSMOLOGICAL MODEL BASED ON AN ASYMMETRIC SCALAR DOUBLET

1.1. Lagrange function and interaction potential

In [1] a cosmological model, based on an asymmetric scalar doublet, that is, a system consisting of two scalar fields – a classical field, Φ, and a phantom field, φ – was proposed and partially investigated. A qualitative analysis was also performed for the case of free scalar fields interacting with each other only via gravitation, and it was conjectured that even a weak phantom scalar field might be able to have a substantial effect on the dynamics of the cosmological model. However, in [1], first of all, some errors were made in the course of the qualitative analysis of the dynamical system, and on top of that, no systematic numerical modeling was performed to elucidate unique features of the cosmological model. We attempt here to correct the indicated shortcomings, and we will also give an energy-based interpretation of the obtained results.

The Lagrange function of a scalar doublet consisting of a classical and a phantom scalar field with self-action in Higgs form with minimal coupling has the form [1]

$$L = \frac{1}{8\pi}(g^{ik}\Phi_{,i}\Phi_{,k} - 2\,\mathrm{V}(\Phi)) - \frac{1}{8\pi}(g^{ik}\varphi_{,i}\varphi_{,k} + 2\,\mathrm{v}(\varphi))\,, \tag{1}$$

where

N. I. Lobachevsky Institute of Mathematics and Mechanics of Kazan Federal University, Kazan, Russia, e-mail: ignatev_yu@rambler.ru; irina_kokh@rambler.ru. Translated from Izvestiya Vysshikh Uchebnykh Zavedenii, Fizika, No. 6, pp. 72–81, June, 2018. Original article submitted March 14, 2018.